PERMIAN AMMONOIDS OF RUSSIA AND AUSTRALIA

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Comparison of the Asselian, Sakmarian, Artinskian, Kungurian and Roadian ammonoid assemblages from the Urals, Novaya Zemlya, North-East of Russia and from Western and Eastern Australia is done. The maximum resemblanee between the ammonoid assemblages of these regions oceurred in the Sakmarian. After this time the differenees beeame greater, some typieal Tethyan taxa appeared in Australian basins. Presenee of the genus *Daubichites* allows the eorrelation of the host roeks in Western Australia and Novaya Zemlya with the Roadian.

RUSSIA and Australia are known as regions where Permian ammonoids are widespread. Permian palaeobasins of the Urals, Novaya Zemlya and the North-East of Asia oecurred to the north of the tropical zone, whereas Permian basins of Western and Eastern Australia occurred to the south of the it. In accordance with the palaeobiogeographic data many workers regard the faunal assemblages of these regions as moderately warm elimatie zones. The majority of workers who studied ammonoid faunas of Australia and Russia over the last six decades recognised many common features in the taxonomic eomposition and morphology of both faunas.

Other regions where Permian ammonoids are also found are not considered in the present paper since they are referred to the Tethyan and North American palaeogeographie realms. The comparison with these faunas is beyond the scope of the present study sinee the assemblages of different climatic zones are strikingly different.

This paper focuses on the eomparison and analysis of the existing data on Permian ammonoids from Russia and Australia to reveal their similarities and differences and their correlative potential.

Ammonoid genera	Urals	North-East of Russia
Aristoceras	+	
Neoglaphyrites	+	
Boesites	+	
Daixites	+	
Prothalassoceras	+	
Glaphyrites	+	
Emilites	+	
Artinskia	+	
Shikhanites	+	
Protopopanoceras	+	
Svetlanoceras	+	
Sakmarites	+	
Almites	+	
Prostacheoceras	+	
Metapronorites	+	+
Eoasianites	+	+
Neoaganites	+	+
Somoholites	+	+
Preshumardites	+	+
Neopronorites	+	+
Agathiceras	+	+
Juresanites	+	+
Tabantalites	+	+
Bulunites		+

Table 1. Asselian ammonoid assemblage.

ASSELIAN

(Table 1)

The ammonoid assemblages of this age are recognised only from Russia (the Urals and the North-East of Russia). Ruzhencev (1952) and Bogoslovskaya et al. (1995) reported 23 genera with more than 30 species from the Asselian rocks of the Urals. These are *Boesites*, *Metapronorites*, *Neopronorites*, *Sakmarites*, *Daixites*, *Artinskia*, *Shikhanites*, *Aristoceras*, *Prothalassoceras*, *Agathiceras*, *Eoasianites*, *Neoglaphyrites*, *Neoaganides*, *Somoholites*, *Preshumardites*, *Glaphyrites*, *Svetlanoceras*, ***Juresanites***, *Almites*, *Emilites*, ***Tabantalites***, ***Prostacheoceras*** and ***Protopopanoceras***. (Here and further on the names of the genera that appeared during the time span under consideration are in bold italics.) Many of the above taxa continued from the Carboniferous. However, the first representatives of the three families, Paragastrioceratidae (*Svetlanoceras*), Metalegoceratidae (*Juresanites*), and Popanoceratidae (*Protopopanoceras*) appeared at the Carboniferous–Permian boundary. The fourth family which indicates the beginning of the

Permian, i.e., Perrinitidae, is unknown from the regions under consideration. In addition, new genera appeared in previously existing families. These are *Sakmarites*, *Sikhanites*, *Prostacheoceras*, *Tabantalites* and *Kargalites*.

The Asselian assemblage from the North-East of Asia is much less diverse than that of the Uralian region and is represented by only nine genera (Andrianov 1985). These are *Metapronorites*, *Neopronorites*, *Prouddenites*, *Agathiceras*, *Somoholites*, *Preshumardites*, *Juresanites*, *Tabantalites* and *Bulunites*, the last genus being endemic. The similarity of the Uralian and North-Eastern regional assemblages at the generic level is clear, while the species representing these genera in the areas under study are also closely similar.

At present no Asselian ammonoids are known from the Permian rocks of Australia.

SAKMARIAN

(Table 2)

A very rich ammonoid assemblage is known from the Sakmarian of the Urals. It includes 27 genera with about 40 species (Ruzhencev 1951, 1952). These are *Boesites*, *Daixites*, *Metapronorites*, *Neopronorites*, *Sakmarites*, *Synartinskia*, *Artinskia*, *Medlicottia*, *Prothalassoceras*, *Thalassoeeras*, *Agathiceras*, *Somoholites*, *Preshumardites*, *Glaphyrites*, *Svetlanoceras*, *Synuraloeeras*, *Uraloceras*, *Paragastrioeeras*, *Juresanites*, *Metalegoceras*, *Parametalegoeeras*, *Kargalites*, *Almites*, *Crimites*, *Tabantalites*, *Prostacheoceras* and *Propopanoeeras*. The Sakmarian ammonoid assemblage from the Urals includes 10 first appearances of genera which are more phylogenetically advanced than the Asselian taxa. The genus *Kargalites* is recorded only from the Sakmarian of the Urals, whereas in other regions it is found in the Asselian. The species of pre-existing genera are phylogenetically more advanced forms.

In the North-East of Asia the Sakmarian ammonoid assemblage is represented by eight species (Andrianov 1985). These are *Metapronorites*, *Neopronorites*, *Somoholites*, *Preshumardites*, *Eoasianites*, *Bulunites*, *Paragastrioeeras* and *Uraloceras*. The appearance of *Paragastrioceras* and *Uraloceras* among the pre-existing Late Carboniferous–Asselian genera allows the correlation of the host rocks with the synchronous Uralian ones, where newly appeared generic taxa also occur with continued earlier genera.

Sakmarian ammonoids in Australia are recognised from the western sedimentary basins (Perth, Carnarvon and Canning) and are represented by six genera (Archbold & Dickins 1996). These are *Svetlanoceras* (or *Uraloeeras*) *irwinense* (one species), *Juresanites jacksoni* (one species), *Metalegoeeras* (three or four species), ?*Mescalites*, *Thalassoeeras wadei* (one species), *Propopanoceras ruzhencevi* (one species). All these genera except for *Mescalites* are known from the Sakmarian of the Urals. The dating is confirmed by the level of evolutionary development of the species of the above genera. The present author considers that *Uraloceras irwinense* Teichert & Glenister, 1952 which was redescribed by Glenister (1990a) as *Svetlanoceras irwinense* (transitional to *Uraloceras*) although showing transitional features fits more closely the diagnosis of *Uraloceras*, including the relative whorl height, overlap degree and the width of the ventral prongs (all features observable in Glenister et al. 1990a: table 1, fig. 2: *1*, *4*, *5*, *7–9*; fig. 3: *1*, *2*, *5*).

Ammonoid genera	Urals	North-East of Russia	Western Australia	Eastern Australia
Boesites	+			
Daixites	+			
Prothalassoceras	+			
Glaphyrites	+			
Emilites	+			
Sakmarites	+			
Tabantalites	+			
Almites	+			
Synartinskia	+			
Synuraloceras	+			
Parametalegoceras	+			
Artinskia	+			
Kargalites	+			
Prostacheoceras	+			
Crimites	+			
Medlicottia	+			
Somoholites	+	+		
Preshumardites	+	+		
Neopronorites	+	+		
Agathiceras	+	+		
Paragastrioceras	+	+		
Uraloceras	+	+	?+	
Svetlanoceras	+		?+	
Juresanites	+		+	
Propopanoceras	+		+	
Thalassoceras	+		+	
Metalegoceras	+		+	
Metapronorites		+		
Eoasianites		+		
Bulunites		+		

Table 2. Sakmarian ammonoid assemblage.

ARTINSKIAN

(Table 3)

Artinskian rocks in the Urals contain 23 ammonoid genera (Ruzhencev 1956; Bogoslovskaya 1962). These are *Daraelites*, *Neopronorites*, *Sakmarites*, *Artinskia*, *Medlicottia*, *Aktubinskia*, *Artioceras*, *Propinacoceras*, *Agathiceras*, *Thalassoceras*, *Paragastrioceras*, *Uraloceras*, *Neoshumardites*, *Metalegoceras*, *Eothinites*, *Kargalites*, *Almites*, *Cardiella*, *Crimites*, *Neocrimites*, *Waagenina*, *Prostacheoceras* and *Popanoceras*. The genera *Aktubinskia*, *Agathiceras* and *Neoshumardites* are restricted to the lower substage, whereas *Propinacoceras*, *Eothinites*, *Waagenina* and *Neocrimites* to the upper substage. Each substage contains different species of the above genera and different proportions of the number of individuals (Ruzhencev 1956).

From the Artinskian of the North-East of Asia Andrianov (1985) reported *Metapronorites*, *Neopronorites*, *Neoshumardites*, *Metalegoceras*, *Paragastrioceras*, *Uraloceras*, *Eotumaroceras* and *Tumaroceras*. The last two genera appeared only in the Artinskian and were endemic. Generally this ammonoid assemblage allows precise correlations with the Artinskian of the Urals.

According to several authors (Teichert 1942; Teichert & Fletcher 1943; Glenister & Furnish 1961; Cockbain 1980; Archbold & Dickins 1996; et al.) the Artinskian in Australia contains *Pseudoschistoceras*, *Bamyaniceras*, *Metalegoceras* and *Neocrimites* (or *Aricoceras*) (Western Australia) and *Uraloceras*, *Gobioceras* and *Aricoceras* (or *Neocrimites*) (Eastern Australia). The presence of *Uraloceras*, *Metalegoceras* and *Neocrimites* allows correlation with the Urals, whereas the presence of *Bamyaniceras* and *Aricoceras* permits correlation of this assemblage with the Yaktashian and Bolorian of the Tethys. The present author's opinion (Leonova & Bogoslovskaya 1990) that it is more preferable to consider as *Aricoceras* the forms described as *Neocrimites* by Teichert & Fletcher (1943) (see also Glenister & Furnish 1961). For the genus *Neocrimites*, the most characteristic feature is the relationship of width to diameter which is always above 1.0 and can reach 1.6–1.8 (as in *Neocrimites pavlovi*). But for the holotype of Australian '*Neocrimites*' the ratio recorded is only 0.63 (Glenister & Furnish 1961: 730). Already in the Artinskian the ammonoid fauna of Australia is considerably different from the Uralian and North-Eastern Asian assemblages of Russia.

Ammonoid genera	Urals	North-East of Russia	Western Australia	Eastern Australia
Artinskia	+			
Agathiceras	+			
Sakmarites	+			
Almites	+			
Prostacheoceras	+			
Crimites	+			
Medlicottia	+			
Aktubinskia	+			
Artioceras	+			
Eothinites	+			
Waagenina	+			
Daraelites	+			
Popanoceras	+			
Cardiella	+			
Kargalites	+			
Thalassoceras	+			
Propinacoceras	+			
Neopranorites	+	+		
Paragastrioceras	+	+		
Neoshumardites	+	+		
Metalegoceras	+	+	+	
Uraloceras	+	+		+
Neocrimites	+		?+	?+
Eotumaroceras		+		
Tumaroceras		+		
Bamyaniceras			+	
Aricoceras			?+	?+
Pseudoshistoceras			+	
Gobioceras				+

Table 3. Artinskian ammonoid assemblage.

KUNGURIAN

(Table 4)

Kungurian rocks of the Urals are known to contain an impoverished ammonoid assemblage indicating

Ammonoid genera	Urals	North-East of Russia	Western Australia	Eastern Australia
Medlicottia	+			
Thalassoceras	+			
Uraloceras	+			
Neopronorites	+	+		
Tumaroceras	+	+		
Epijuresanites	+	+		
Paragastrioceras	+	+	+	
Neouddenites		+		
Baraioceras		+		
Bamyaniceras			+	
Aricoceras				+

Table 4. Kungurian ammonoid assemblage.

a shallow water basin with increasing abnormal salinity. According to Bogoslovskaya (1976) only a few species including *Neopronorites*, *Thalassoceras*, *Paragastrioceras* and *Uraloceras* may positively be determined from the Kungurian of the Middle Urals. According to the most recent data, *Medlicottia postorbignyana* and *Tumaroceras dignum* are recognised from the more northern regions of the Urals (Pai-Khoi) and *Epijuresanites vaigachiensis* from Vaigach Island (Bogoslovskaya 1997). At present there are seven genera and nine species constituting the Kungurian assemblage of the Middle and Northern Urals. Bogoslovskaya (1997) has indicated that the more advanced new species of *Medlicottia*, and the first discovery of representatives of genera *Tumaroceras* and *Epijuresanites* in this region. These data allow precise correlation with the Kungurian of the North-East of Russia.

Kungurian rocks of the North-East of Russia represented by the normally marine facies and salinity contain a richer ammonoid assemblage including *Neopronorites*, *Neouddenites*, *Paragastrioceras*, *Tumaroceras*, *Epijuresanites* and *Baraioceras* (Andrianov 1985). Two of these genera are endemic, although the appearance of the genus *Epijuresanites*, representing a new family *Spirolegoceratidae*, distinctly separates this stage from the previous. The presence of the genera *Paragastrioceras*, *Tumaroceras* and *Epijuresanites* permits precise correlation both of these regions.

Only preliminary conclusions may be made regarding the Kungurian ammonoids from Australia since Cockbain (1980) correlated the Kungurian with the Roadian whereas Archbold & Dickins (1996) recognised that the Ufimian–Roadian were post-Kungurian which has resulted in some problems in the dating of ammonoid-bearing rocks. Apparently, the assemblage includes *Uraloceras pokolbiense*, *Aricoceras meridionale* and *Gobioceras lobulatum* from Eastern Australia, and *Paragastrioceras wandageense* and *Bamyaniceras australe* from Western Australia, i.e. the genera that also occur in the Artinskian. As was mentioned by Bogoslovskaya (1976) and Archbold & Dickins (1996) *Paragastrioceras wandageense* Teichert (1942) is closely similar to the Uralian species *Paragastrioceras kungurense* (Mirskaya, 1948) from the Late Kungurian deposits of the Middle Urals. Re-examination of the Western Australian holotype specimen confirmed this close relationship. The conclusion that the post-Artinskian sediments do not contain *Paragastrioceras* and *Popanoceras* species (Cockbain 1980) seems doubtful. Species of these genera as well as those of the genus *Aricoceras* are known from rocks of Kungurian age and from the Roadian (Kubergandian) (Bogoslovskaya 1976; Leonova & Bogoslovskaya 1990).

ROADIAN

(Table 5)

Late Permian ammonoids are unknown in the Urals. However a representative assemblage is recorded from Novaya Zemlya (Bogoslovskaya et al. 1982). It includes *Daubichites butakovensis*, *Altudoceras boreum*, *Sverdrupites harkeri* and *S. amundseni* which indicate the Roadian world-wide (Arctic Canada, North-East of Russia, Far East, China, Western Australia).

In the North-East of Russia the Roadian ammonoid assemblage is represented by three genera. These are *Daubichites*, *Sverdrupites*, *Pseudosverdrupites* and *Popanoceras* (Andrianov 1985; Budnikov et al. 1997). This allows the correlation of the host rocks with the Roadian of the above regions.

Ammonoids described from Australia allow the assignment of the host rocks to the Roadian. These are *Daubichites goochi*, *Agathiceras applanatum*, *Bamyaniceras australe* and *Popanoceras* sp. The genus *Daubichites* is the most characteristic of the Roadian. The presence of the other taxa does not contradict this assignment, especially if Glenister and Furnish's (1961) observation is noted that the specimen they described belonged to an 'advanced species of *Popanoceras*'. The present author's opinion is that *Agathiceras applanatum* has some specific features, that could be considered as characteristic for a Late Permian representative of this genus, such as subparabolic cross-section of whorl and very wide ventral lobe. This species is more similar with the Sicilian species of *Agathiceras* than with Early Permian ones.

Ammonoid genera	Novaya Zemlya	North-East of Russia	Western Australia	Eastern Australia
Altudoceras	+			
Sverdrupites	+	+		
Daubichites	+	+	+	
Pseudosverdrupites		+		
Popanoceras		+	+	
Bamyaniceras			+	
Agathiceras			+	

Table 5. Roadian ammonoid assemblage.

The youngest species described from the Permian of Western Australia is *Cyclolobus persulcatus* recognised on the basis of a single specimen from Canning Basin, Western Australia (Glenister et al. 1990b). Since such high horizons of the Permian in Russia are known only in the Far East, correlation may be made with the Ljudjansinian Horizon having Capitanian–Dhulfian age. This region is referred to the Tethyan Palaeobiographical Realm.

CONCLUSIONS

1. The review clearly shows that both in Russia and Australia the Lower Permian is better characterised by ammonoids.
2. The maximum resemblance between the ammonoid assemblages of 'Boreal' regions of Russia and Australia occurred in the Sakmarian.
3. From the Artinskian the differences in the generic composition of synchronous ammonoid assemblages became greater, while the typical Tethyan taxa such as *Bamyaniceras* and *Aricoceras* played an increased role in Australian basins.
4. The data on accompanying fossils should be analysed to control the dating of the Kungurian in the Australian sections.
5. The genus *Daubichites* play an important role in the correlation since it widely occurrs in the Roadian of the Arctic Realm, Far East, China and Australia.

Due to the absence of the necessary data wide correlations between the remaining part of the Upper Permian sequence are impossible.

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